CALIFORNIA DIVISION OF MINES AND GEOLOGY
FAULT EVALUATION REPORT FER-175

Rinconada Fault (Espinosa and San Marcos Segments), Monterey and San Luis Obispo Counties

by
Earl W. Hart
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INTRODUCTION

The Rinconada and related faults constitute a major element of the San Andreas fault system and extend 140 miles (230 km) from the Big Pine fault on the south to King City on the north (Dibblee, 1976; Figure 1). The fault may extend another 35 to 50 miles (56 to 80 km) northwest along what is variously termed the Reliz fault (Dibblee), King City fault (Jennings, 1975) or King City-Reliz fault (Buchanan-Banks and others, 1978). According to Dibblee, the Rinconada-Reliz fault zone has been active mainly during late Cenozoic time, with as much as 35 miles (56 km) of right-lateral displacement since early Miocene time and 11 miles (18 km) since early Pliocene time. Major truncation of the Paso Robles Formation (Plio-Pleistocene) indicates that faulting continued well into Pleistocene time. Apparent offset of older alluvium and right-lateral deflections of principal drainages indicate that the movement continued into late Pleistocene time locally, although in many places late Pleistocene and Holocene units are not mapped as being faulted (Dibblee, 1971 and 1976; Hart, 1976). Evidence of Holocene activity is slight and inconclusive (Dibblee; Hart; Buchanan-Banks and others).

The purpose of this evaluation is to determine if any of the segments of the Rinconada and Reliz faults meet the criteria of "sufficiently active and well-defined" to warrant zoning under the Alquist-Priolo Special Studies Zones Act (Hart, 1985). However, severe time constraints prevent a careful evaluation of this long fault. Therefore, the Nacimiento segment of the Rinconada fault (Figure 1) is not considered herein, because it lies in relatively remote terrain and no evidence of late Quaternary activity is known for that segment (Dibblee, 1976; Buchanan-Banks and others, 1978).

To further expedite this evaluation, the fault segments northwest of the Rinconada Mine (Figure 1) were evaluated only in a preliminary way. A reconnaissance review of aerial photographs (USDA, 1949; USDA, 1956; USGS, 1974) was made to further focus the effort on segments of the Rinconada fault that appear to be both well-defined and recently active. Only the Espinosa and San Marcos segments of Dibblee (1976) appear to meet these criteria and are singled out for more careful scrutiny (Figure 1). The Reliz fault and Rinconada segment of the Rinconada fault to the north and south, respectively, were rather poorly-defined geomorphically and are not evaluated further in this report. Additional information on these segments, both of which are reported to have been active in late Quaternary time, is contained in Dibblee (1976), Buchanan-Banks and others (1978) and Hart (1976).

SUMMARY OF AVAILABLE DATA

The Espinosa and San Marcos segments of the Rinconada fault have been mapped in moderate detail by T.W. Dibblee (1971) and by D.L. Durham (1964, 1965a, 1966, 1968a, 1968b). Their work is summarized by Dibblee (1976) and

Durham (1965b and 1974) and has been compiled by Jennings (1975) and Buchanan-Banks and others (1978). Because of time constraints, the work of others is not reviewed here, and the reader is referred to Dibblee (1976) for a more complete summary of these faults. The Espinosa and San Marcos segments were named by Dibblee (1976), who considered the Espinosa and San Marcos faults of earlier workers to be northern segments of the Rinconada fault to the south.

Espinosa Segment

This segment of the Rinconada fault was identified by Dibblee (1976) as a 25-mile long segment of the Rinconada fault that connects with the San Marcos segment to the southeast. To the northwest, the segment dies out west of King City before reaching the Reliz fault, with which it aligns. The individual strands of the fault were mapped by Dibblee (1971). The fault segment largely coincides with the Espinosa fault of Durham (1964; 1965a; 1966; 1974) and other workers (summarized by Dibblee, 1976). Except for the northern end of this segment, the principal traces mapped by Dibblee (1971) are plotted on Figure 2a.

According to Dibblee (1976, p. 24, Figure 14), a number of drainages that cross the fault are deflected systematically in a right-lateral sense, suggesting right-lateral displacement in "very late Quaternary time." Dibblee (1971) also shows the Paso Robles Formation (Plio-Pleistocene) and older alluvium (Pleistocene) to be offset in several places (Figure 2a). However, the older alluvium is not shown to be offset south of Williams Hill. He also indicates that Holocene alluvium may be offset against older alluvium in Williams Canyon. This may be a drafting error as Dibblee does not discuss this in the text and Holocene alluvium is shown to conceal the fault elsewhere to the north and south. For the most part, the Espinosa segment lies in the upper Monterey Formations of late Miocene age. This unit is deformed into may tight folds, which trend more westerly than the fault and do not cross the fault strands (Dibblee, 1971; 1976). Dibblee attributes this to drag along the Espinosa segment of the Rinconada fault.

A westerly strand, identified is the San Antonio fault (Figure 2a), is shown by Dibblee (1971, 1976) to be a steep to northeasterly-dipping reverse fault which truncates and partly overturns beds of the Monterey Formation and the Paso Robles Formation. Pleistocene alluvium is not shown to be offset by the San Antonio fault.

Durham (1964; 1965a; 1966; 1974) mapped the San Marcos and San Antonio faults somewhat similarly (but different in detail). The youngest unit shown to be faulted is the Monterey Formation. Older alluvium is not shown to be faulted where mapped. His data are not plotted in Figure 2a.

San Marcos Segment

The San Marcos segment of the Rinconada fault of Dibblee (1976) extends from the Espinosa segment southeastward to Paso Robles, where it complexly joins the more northerly trending Rinconada segment (Figure 1). As mapped by Dibblee, (1971), the segment consists of a single main strand that is quite linear northwest of the Nacimiento River. To the southeast, the segment is a complex of several strands that are somewhat sinuous. Based on physiographic, stratigraphic and structural evidence, Dibblee (1976) considers the San Marcos segment to have major right-slip displacement since Miocene time. He indicates that much of the displacement occurred prior to deposition of the Paso Robles Formation, although the latter unit is offset against Monterey Formation in several places. Dibblee's (1971) data are summarized on Figure 2b, except for the southeastern portion of the segment (which is not very well defined geomorphically) near Paso Robles. Nowhere does he indicate that Pleistocene or Holocene alluvial units are offset by this segment.

The San Antonio fault is another important fault that Dibblee (1971, 1976) shows along the northeast side of San Antonio Reservoir. He considers the fault to be partly reverse (north eastside up) in that area, but to merge with the Rinconada fault to the southeast. The youngest unit offset by the San Antonio strand is the Paso Robles Formation.

Other geologists have mapped elements of the San Marcos segment of the Rinconada fault (Dibblee, 1976). The most recent previous work was by Durham (1968a, 1968b, 1974), who identified the various faults as elements of the San Marcos, San Antonio, Jolon, and Espinosa faults. Although his interpretation of map units and fault locations differ somewhat from Dibblee (1971), Durham also shows the Paso Robles Formation to be the youngest unit faulted. Pleistocene and Holocene units along the San Antonio and Nacimiento Rivers are not shown to be faulted. According to Durham (1965b), the San Marcos fault has had about 11 miles of right-lateral displacement since Pliocene time. Durham's data are not plotted on Figure 2a.

SEISMICITY

According to "A" and "B" quality epicenters identified from 1969 to 1984 (U.S. Geological Survey, 1985), there is little evidence to clearly identify the Espinosa and San Marcos segments of the Rinconada fault as seismically active. However, several small earthquakes have been recorded within a few miles of th Espinosa and San Marcos segments (Figure 3a and 3b), which suggests that these segments may be active locally.

Because of inadequate instrumentation in the region partly during and prior to the 1969-1984 period, other earthquakes ("C" quality or worse) cannot be located with sufficient accuracy to be associated with specific faults.

A few damaging earthquakes also have been reported in the region (e.g. in 1852, 1885 and 1952), but they too cannot be realted to specific faults. The only possible evidence of surface faulting was the 30 miles of fissures reported in Lockwood Valley in association with an earthquake in October or November 1852 (Townley and Allen, 1939, p. 28-29; Toppozada, Real and Parke, 1981). Unfortunately, there are two "Lockwood Valleys" (Monterey and Ventura Counties) in California. Judging from the lack of rupture evidence along the Rinconada fault near Lockwood Valley in Monterey County (see below), which lies west of Williams Hill, and the reported area of shaking (San Simeon to San Diego and the Colorado River), the Rinconada fault does not appear to be the source for this earthquake. Other information of damaging earthquakes is summarized by Townley and Allen (1939) and Richter (1969).

INTERPRETATION OF AERIAL PHOTOGRAPHS AND FIELD OBSERVATIONS

Aerial photographs of the U.S. Department of Agriculture (USDA 1949 and 1956) and U.S. Geological Survey (1974) were inspected in a reconnaissance way between the Rinconada Mine and Salinas to determine the existence of well-defined and recently active segments of the Rinconada and Reliz faults. (Figure 1). The best-defined segments were along portions of the Espinosa and San Marcos segments, which were interpreted in greater detail. Subsequent field checking of selected portions of these faults was done September 11 and 12, 1985. The photographic and field interpretations are plotted on Figure 2a and 2b.

The gross geomorphic features and truncation of units are very indicative of the location, recency, and sense of displacement of the Rinconada fault. The principal traces of the fault are well defined by the alignment of drainages, troughs and scarps, as well as the apparent truncation of the well-bedded Monterey Formation. Right-lateral displacement of large magnitude is strongly suggested by the right bends and deflections of most of the larger to intermediate-sized drainages, some of which are beheaded or otherwise disrupted across the main fault strands. Although the observed features are strongly suggestive of late Quaternary activity, the lack of clearly offset alluvium of latest Pleistocene and Holocene ages and the presence of some drainages that are not deflected right-laterally suggest that the Espinosa and San Marcos segments of the Rinconada fault may not have been active in latest Quaternary time or now have a very low slip-rate.

Espinosa Segment

This segment is well defined as a single strand between Williams Canyon in the Williams Hill quadrangle and Seven Wells Canyon in the Espinosa quadrangle (Figure 2a). The almost continuous trace mapped is virtually coincident with the main and western traces of Dibblee (1971). The fault is difficult to trace northwest of Seven Wells Canyon and southeast of Williams Canyon. The eastern and other traces of Dibblee could be verified only locally by subtle, permissive geomorphic features, but mostly were not well-defined.

The best evidence for recency is the apparent truncation of older alluvium and associated alluvial fan surfaces which abruptly terminate against an east-facing scarp between Loeber and Glau Canyons near Williams Hill (Locality 1, Figure 2a). The older alluvium is probably of late Pleistocene age, based on the moderate preservation of fan surfaces and development of reddish soil. However, no evidence of faulting was observed in alluvium exposed in gullies inspected along the projected trace of the fault. An old adobe structure, which conceivably could pre-date the 1852 "Lockwood Valley" earthquake, was observed within 50 feet of the fault trace at Locality 1. It showed only minor stress cracks and surely would not survive local earthquakes of even moderate intensity along the Rinconada fault without greater damage. Also, the ground surface along the fault trace lacked any evidence suggestive of significant historic fault rupture (e.g. moletracks, sharp tonal features, scarplets).

Ephemeral features indicative of Holocene or historic ruptures also were not noted elsewhere to north or south. The closed depressions observed in the field at localities 2, 3, and 5 all appear to be caused by debris flow and landslide deposits blocking the ephemeral drainages, which do not have active, incised channels. Other closed depressions, noted away from faults in San Lucas, Weferling and ~~which~~ Espinosa Canyons, also appear to be caused by drainages blocked by debris flow and landslide deposits.

Field evidence suggestive of Holocene activity along the Espinosa segment also was lacking at other observed localities, including Espinosa and Pine Canyons and north of Jolon Road. The southward connection of the Espinosa segment with the San Marcos segment was not particularly well-defined and lacked evidence for recent displacement.

San Marcos Segment

This segment is not as well-defined as the Espinosa segment, except for a 3-mile segment east of the San Antonio Reservoir (Figure 2b). At that locality, a single trace can be inferred from the almost continuous alignment of linear and right-deflected drainages, saddles, benches and weak tonals evident on aerial photographs. However, ephemeral, fault-produced, geomorphic features (such as scarps, sidehill-benches) were not observed in the field and minor drainages were not offset. The closed depressions noted at Locality 6 (Figure 2b) were shallow and apparently caused by debris flows and landslides blocking ephemeral drainages. Geomorphic evidence of this trace could not be mapped as far south as San Antonio River, although the river appears to be right-laterally deflected on trend with the trace.

Between the San Antonio and Nacimiento Rivers, a fairly linear trace of the Rinconada fault is evidenced by the alignment of linear drainages and other features suggestive of recent right-lateral faulting (Figure 2b). That segment was not carefully field-checked, although the geomorphic features were comparable to features noted north of San Antonio River. No evidence of recent faulting was observed along Sulphur Canyon Road, which was checked briefly in the field.

South of the Nacimiento River, the San Marcos segment is defined by several weakly to moderately defined traces that are partly obscured by landslides. The traces appear to splay southward in a broad zone near San Marcos Creek, which is broadly deflected in a right-lateral sense. My traces do not agree with those mapped by Dibblee (1971) in this area (Figure 2b) and none of the traces were field-checked. The segment could not be mapped with confidence to the southeast of San Marcos Creek.

CONCLUSIONS

The Espinosa and San Marcos segments constitute the two most northerly segments of the important Rinconada fault. These segments reportedly connect with the Rinconada segment to the south and align with the Reliz fault to the north (Figure 1; Dibblee, 1976). These faults are considered to be elements of the San Andreas fault system.

As much as 35 miles (56 km) and 11 miles (18 km) of right-lateral displacement are reported since early Miocene and early Pliocene time, respectively. Major displacement of undetermined magnitude also has occurred since Plio-Pleistocene time and apparently has continued into late Quaternary time (Dibblee, 1976). Evidence of late Quaternary displacement is indirect but fairly strong, judging from the preponderance of right-laterally deflected drainages and other well-defined, large-scale geomorphic features observed on aerial photographs. Also, older alluvial fans of probable late Pleistocene age appear to be truncated northwest of Williams Hill, although faults were not exposed in gullies incised into that unit where it is crossed by the mapped trace.

The general lack of ephemeral, small-scale geomorphic features (e.g. sidehill benches, offset minor drainages, scarplets or sharp tonals in young alluvium) normally associated with active strike-slip faults suggests that the fault has been inactive during Holocene time or that the fault has had a relatively low slip rate in Holocene time. Evidence of historic activity was not observed in the field; nor is it adequately supported by the recorded seismicity from 1969 to 1984.

RECOMMENDATIONS

Although much of the Espinosa and San Marcos segments of the Rinconada fault is well-defined, the mapped traces of this writer and others do not appear to be "Sufficiently active" (i.e. Holocene) to warrant zoning under the Alquist-Priolo Special Studies Zones Act (Hart, 1985, p.5). Therefore, zoning of these segments is not recommended at this time.

Earl W. Hart
Senior Geologist
CEG 935

Earl W. Hart

REFERENCES

Buchanan-Banks, J.M., Pampeyan, E.H., Wagner, H.C., and McCulloch, D.S., 1978, Preliminary map showing recency of faulting in coastal south-central California: U.S. Geol. Survey Map MF-910, 11p., 3 sheets, scale 1:24,000.

Dibblee, T.W., Jr., 1971, Geologic maps of 15-minute quadrangles along the San Andreas fault in vicinity of King City and Paso Robles, California with index map (includes Greenfield, King City, Paso Robles, San Ardo and San Miguel quadrangles): U.S. Geological Survey Open-File maps, scale 1:62,500.

Dibblee, T.W., Jr., 1976, The Rinconada and related faults in the southern Coast Ranges, California, and their tectonic significance: U.S. Geological Survey Professional Paper 981, 55p.

Durham, D.L., 1964, Geology of the Cosio Knob and Espinosa Canyon quadrangles, Monterey County, California: U.S. Geol. Survey Bull. 1161-H, 29p., 4 plates, scale 1:24,000.

Durham, D.L., 1965a, Geology of the Jolon and Williams Hill quadrangles, Monterey County, California: U.S. Geol. Survey Bull. 1181-Q, 27p., 3 plates, scale 1:24,000.

Durham, D.L., 1965b, Evidence of large strike-slip displacement along a fault in the southern Salinas Valley, California, in Geological Survey research 1965: U.S. Geol. Survey Prof. Paper 525-D,p. D106-111.

Durham, D.L., 1966, Geology of the Hames Valley, Wunpost and Valleton quadrangles, Monterey and San Luis Obispo Counties, California: U.S. Geol. Survey Bull. 1121-B, 53 p., 5 plates, scale 1:24,000.

Durham, D.L., 1968a, Geology of the Tierra Redonda and Bradley quadrangles, Monterey and San Luis Obispo quadrangles, California: U.S. Geol. Survey Bull. 1255, 60 p., 4 plates, scale 1:24,000.

Durham, D.L., 1968b, Geologic Map of Adelaida quadrangle, San Luis Obispo County, California: U.S. Geol. Survey Geol. Quad. Map GQ-768, scale 1:24,000.

Durham, D.L., 1974, Geology of the southern Salinas Valley area, California: U.S. Geol. Survey Prof. Paper 819, 111p., 4 pls, scale 1:125,000.

Hart, E.W., 1976, Basic geology of the Santa Margarita area, San Luis Obispo County, California: California Division of Mines and Geology Bulletin 199, 45 p., 1 plate, scale 1:24,000.

Hart, E.W., 1985, Fault-rupture hazard zones in California: California Division of Mines and Geology Special Publication 42, 24p. (revised).

Jennings, C.W., 1975, Fault map of California with locations of volcanoes, thermal springs, and thermal wells: California Division of Mines and Geology Geologic Data Map No. 1, scale 1:750,000.

Richter, C.F. 1969, Possible seismicity of the Nacimiento fault, California: Geological Society of America Bulletin, v. 80, p. 1363-1366.

Toppozada, T.R., Real, C.R., and Parke, D.L., 1981, Preparation of isoseismal maps and summaries of reported effects for pre-1900 California earthquakes: California Division of Mines and Geology Open File Report 81-11SAC, 182p.

Townley, S.D., and Allen, M.W., 1939, Descriptive catalogue of earthquakes of the Pacific Coast of the United States, 1769 to 1928: Bulletin of the Seismological Society of America, v. 29, 297p.

U.S. Department of Agriculture, 1949, Black and white, vertical, aerial photographs of Monterey County, ABG-5F-208 to 213, 6F-4 to 14, 147 to 159, and 169 to 179, 7F-100 to 112 and 129 to 142, 8F-62 to 72 and 110 to 118 and other portions of flight lines 9F to 17F in a northwest direction to Monterey Bay, scale 1:20,000.

U.S. Department of Agriculture, 1956, Black and white, vertical, aerial photographs of San LUis Obispo County, AXH-8R-79 to 82, 11R-173 to 177 and 182 to 192, 12R-37 to 40, 11R-110 to 114, 11R-81 to 85, and other portions of flight lines between Paso Robles and Santa Margarita, scale 1:20,000.

U.S. Geological Survey, 1974, Color, vertical, aerial photographs, SFB (Area 6), 10-6 to 114, scale 1:36,000.

U.S. Geological Survey, 1985, CALNET earthquake data catalogue, 1969-1984 (Preliminary; unpublished data on file with California Division of Mines and Geology).

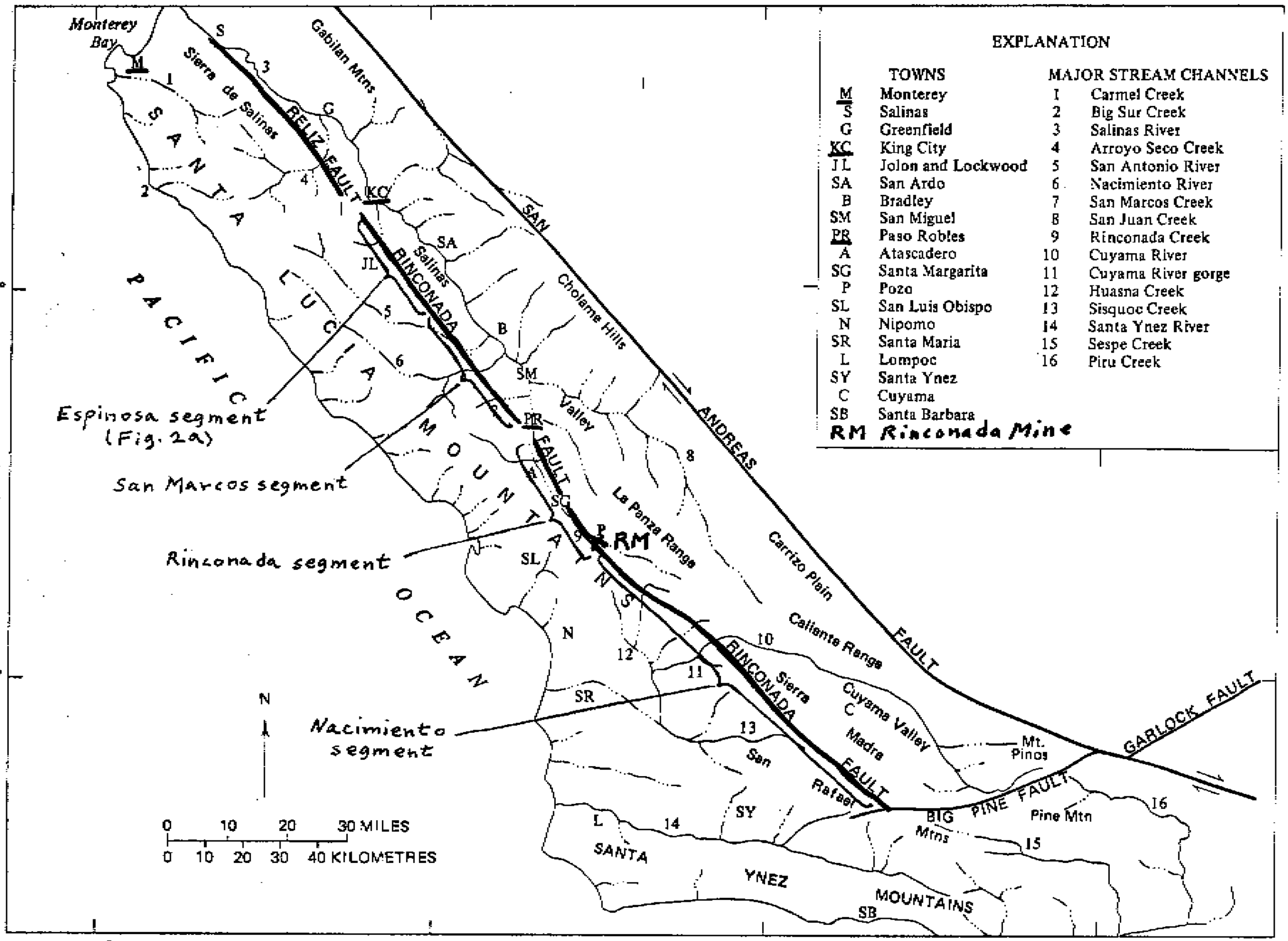

Figure 1 (FER-175). Physiographic features and drainages along and near the Rinconada and Reliz faults.
(Modified from Dibblee, 1976)

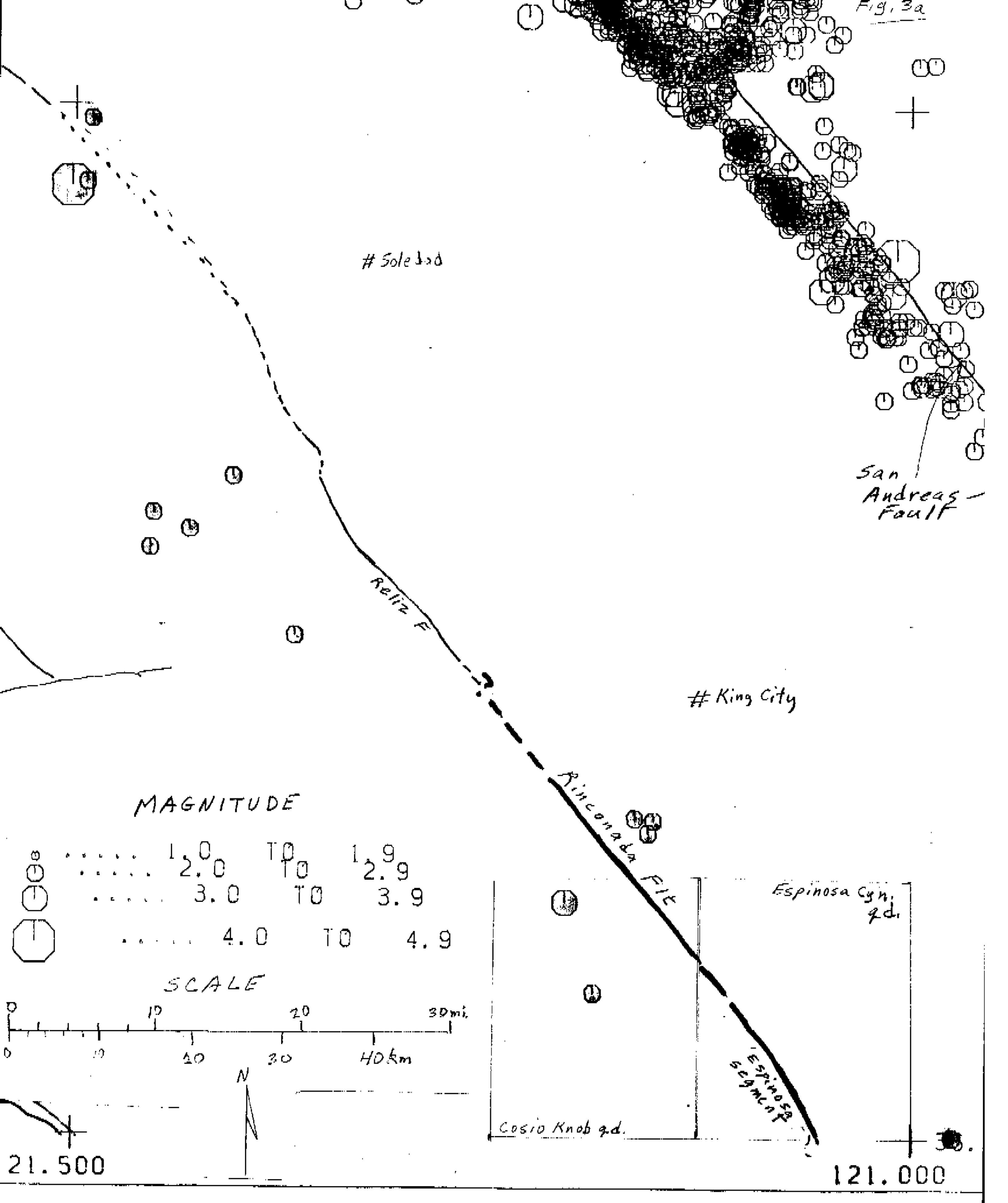

Figure 3a. (FER-175). A and B quality earthquake epicenters near the northern Rinconada fault, 1969-1984 (U.S. Geological Survey, 1985).

Figure 36. (FER-175). A and B quality earthquake epicenters near the southern Rinconada fault, 1969-1984 (U.S. Geological Survey 1985).